Did artificial re-oligotrophication induce a reduction of fish catch in Lake Biwa?

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Recently, decreasing of fish catch has been know in various freshwater and coastal systems in Japan. Artificially lowering nutrient loading, especially phosphorus, by emission regulation is recently considered to be one of the most plausible reasons for the decrease, despite a lot of potential reasons for the decrease, e.g. deteriorating spawning and nursery grounds due to reclamation in shallow coasts and losses of weed beds, and overfishing, proposed. Positive correlation between phosphorus loading and fish catch has been shown in a couple of coastal areas, Harima-nada and Osaka Bay, but few quantitative analyses, e.g. taking ecological transfer efficiency into consideration, have been done before. In Lake Biwa, fish catch also declined after 1990, and positively correlated with total phosphorus (TP) during the last 4 decades, but no quantitative analysis has been done until now.

In our on-going project, we are trying to clarify this relationship through determining zooplankton production and phosphorus dynamics using state-of-the-art techniques, i.e. nano-molar measurements of ortho-phosphate and phosphate oxygen isotope ratio. Until recently, nobody knew true concentrations of ortho-phosphate in oligo- and mesotrophic lakes, such as Lake Biwa, due to under the detection limit of soluble reactive phosphorus measured by traditional molybdenum-blue method. Our new method for measuring ortho-phosphate with nano-molar level using an ion-chromatography allowed us to truly determine dynamics of phosphorus in Lake Biwa, which will be proposed by our collaborators in this session. Apart from this, we have an evidence on regulating zooplankton biomass with fish predation during the last 4 decades. This strong top-down effect on zooplankton implies that bottom-up control on fish production may be unreasonable explanation for recent decline of fish catch in the lake. I’ d like to introduce the story that climatic and anthropogenic effects on zooplankton in this lake could be masked by fish predation.

We analyzed net zooplankton samples collected by Shiga Prefectural Fisheries Experiment Station for the last 4 decades from 1971 to 2010. Size-structure and biomass in crustacean zooplankton were determined and compared with catch per unit effort (CPUE) of dominant zooplanktivorous fish, Ayu (*Plecoglossus altivelis altivelis*). Generalized linear model (GLM) was conducted to clarify which factors, temperature, food abundance (TP) and fish predation (Ayu CPUE), affected on zooplankton community structure and biomass.

Annual mean water temperature above 20 m increased by 0.94°C during the study period. TP as food proxy increased until 1974, and then decreased until 1985, but being stable after that. Ayu CPUE increased up to 6.42 k-tons/net/y until 1987, but declined to 1.04 k-tons/net/y to 2005. Five zooplankton taxa, *Eodiaptomus japonicus*, Cyclopoida spp., *Daphnia* spp., *Bosmina longirostris* and *Diaphanosoma orientalis*, were always dominant throughout the study period. Annual mean total

crustacean biomass varied from 0.3 to 3.6 g dry weight/m^2, slightly decreasing until 1993 but increasing thereafter. GLMs showed that annual mean body sizes were affected by temperature and Ayu CPUE while annual mean biomass was affected by TP and Ayu CPUE. There were no effects during high TP period until 1985, but only Ayu CPUE affected both traits during stable TP period after 1986. These results suggested that both crustacean biomass and body size structure might be strongly affected by fish predation, that effects of eutrophication and global warming would be masked by this top-down effect, and consequently that variation of crustacean biomass could not explain decreasing fish catch in the lake.

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